engineering practices imbedded in the technological approaches such as those espoused by Teletrac and METS should not dictate the use of very scarce spectrum, simply because it is difficult, to achieve certain cost goals.

H. A Personal Locator Service Should Not Drive the FCC's Band Plan

Teletrac has suggested that a personal locator service is an important component of AVM service in the 902-928 MHz band. This contention should be considered according to the overall technical, functional and marketing performance requirements and market size to be addressed.

A vehicular location system, operating as it does from an adequate power source in the vehicle's electrical system, and being carried within or attached to the vehicle, needs to be able to perform the radiolocation function very quickly because of the extremely large number of vehicles requiring service from the system, as discussed above. In certain situations, the location function must occur quickly to meet the needs of some vehicular application for short response times, *i.e.*, "asynchronous-like" operation.[18] The radiolocation function also needs to be performed efficiently to minimize the loss of airtime due to protocols and the time needed to recover low-power signals from

---

[18] As discussed later, the needs for "asynchronous-like" operation are not in conflict with time-division sharing by wide-area systems.

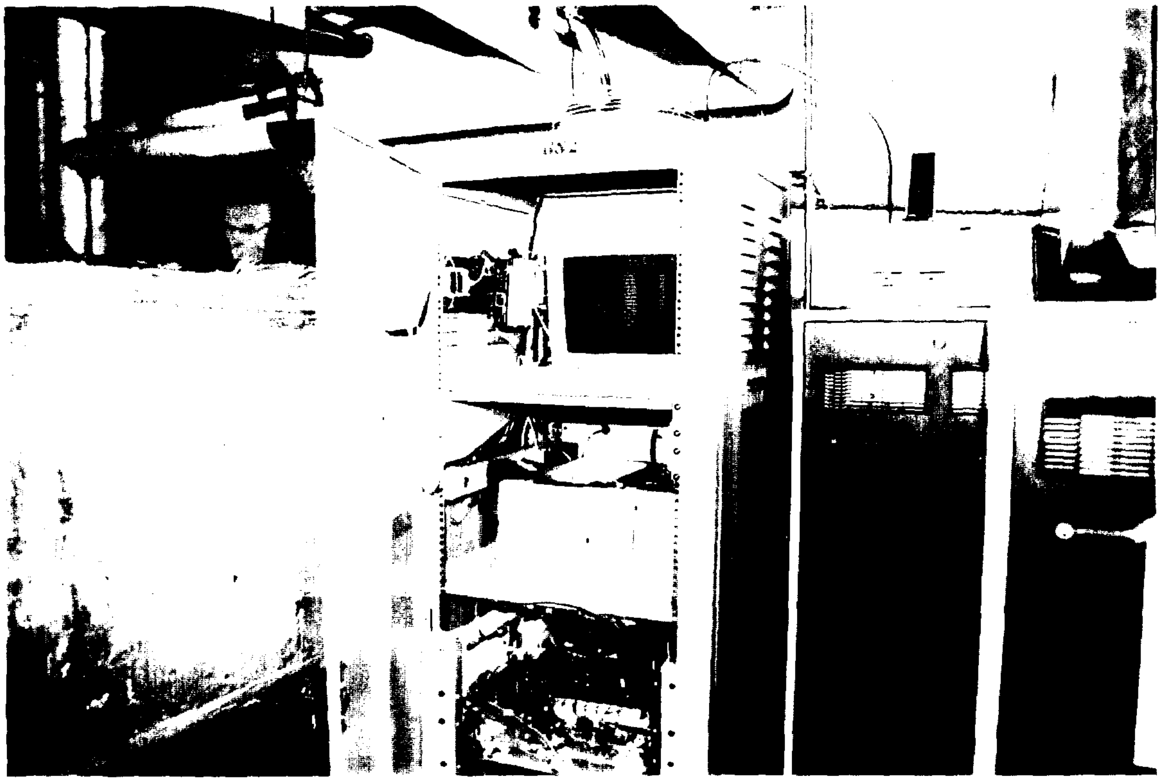
low signal-to-noise ratios. The Cramér-Rao bound shows that to reduce the time necessary to perform a vehicular position fix, the power levels of signal across the terrestrial radiolocation area must be increased relative to ambient noise and interference, especially the power radiated by the mobile, so as to reduce the base station's receiver processing time and to increase the network throughput. This is consistent with the availability of power from the mobile's source, the vehicle operated equipment operating at low output power. Moreover, since a longer time can be taken, considerably less bandwidth is sufficient.

Given these very significant differences, the design and implementation of the efficient vehicular location and management systems would be at great odds with the incorporation of a personal locator functionality in the same systems. Accordingly, personal location and other low power applications -- such as stolen vehicle tracking and law enforcement applications noted by Teletrac -- could be permitted by the FCC, but in a narrowband allocation, possibly outside the AVM allocation, where low background noise levels can allow battery-powered equipment to operate successfully.[20] The desire of one market participant to implement an incompatible personal location system should not hold hostage the competitive implementation of efficient high-speed vehicular systems in the noisier 902-924 MHz AVM band.

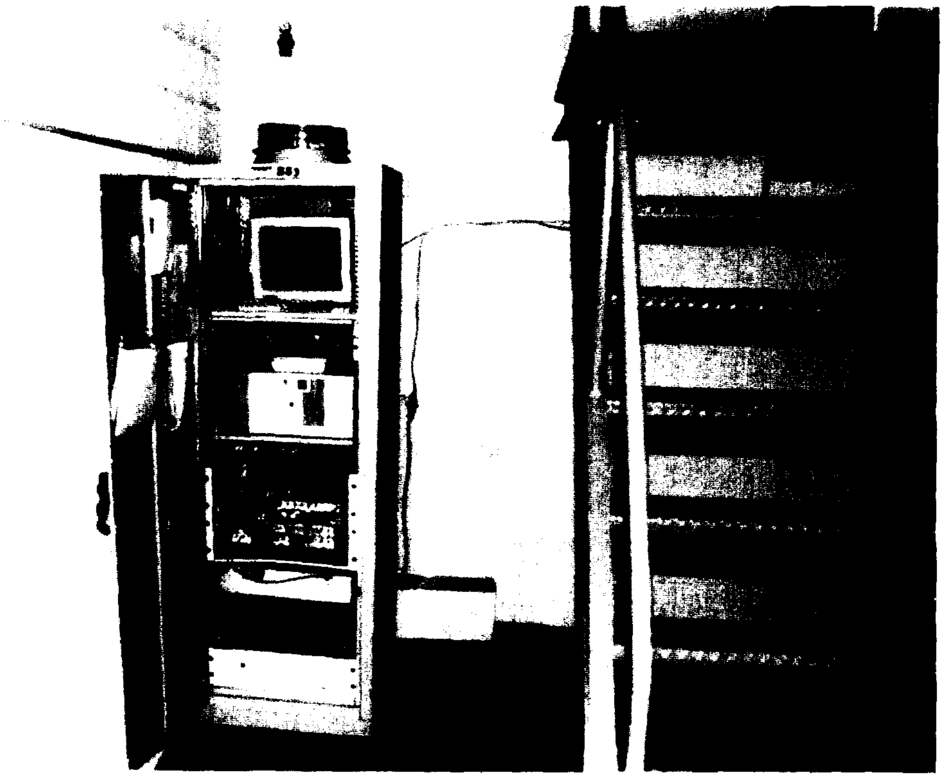
---

[20] For example, some of the reserve spectrum from the FCC's recent narrowband PCS allocation at 901-902, 930-931, and 940-941 could be used for such a service. It should also be possible to make such a service a reality in the 906-910 and 920-924 MHz low noise sub-bands Pinpoint proposed, provided that the operator were willing to devote a substantial amount of its "time resource" to such a use.

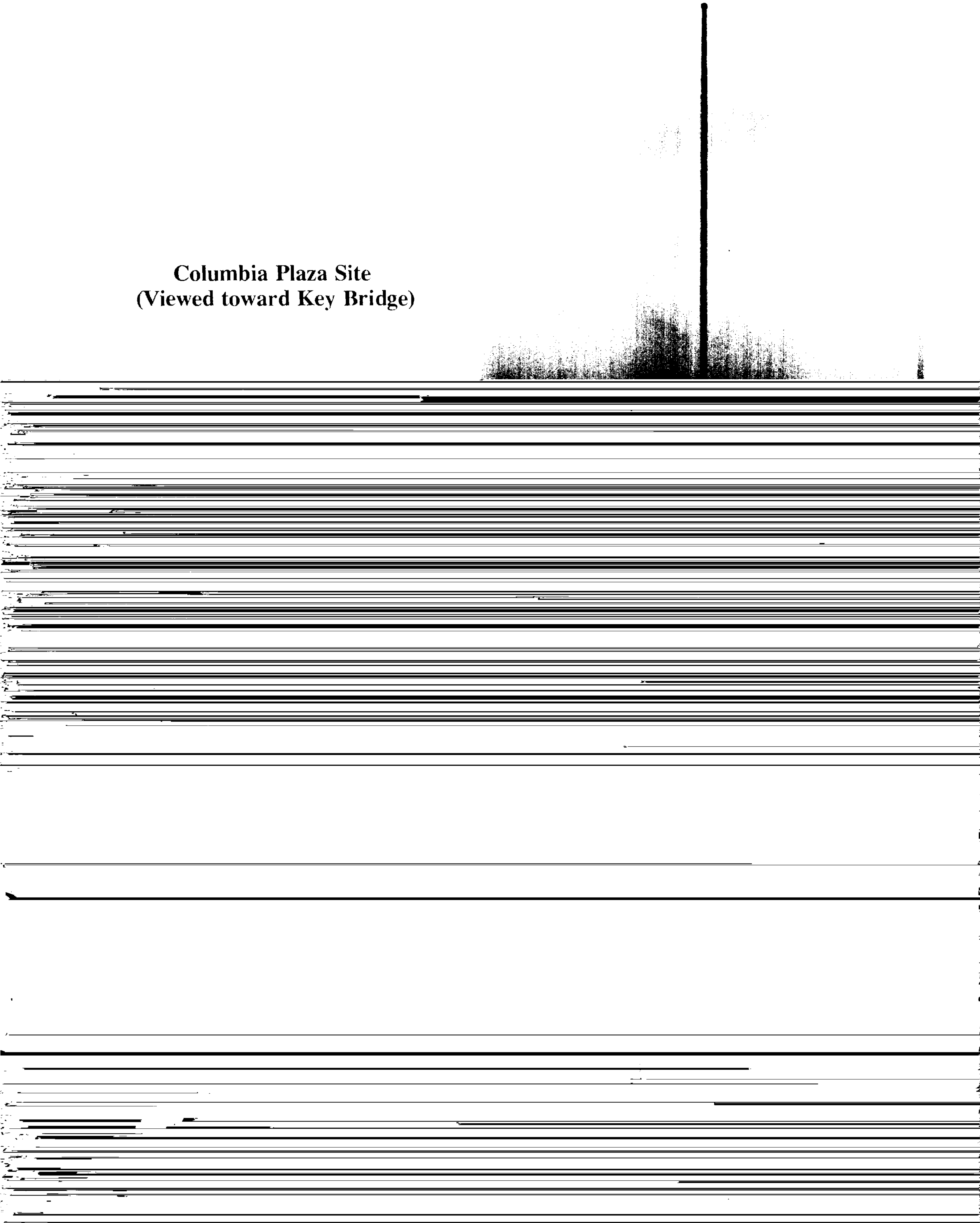
Pinpoint
COMMUNICATIONS, INC.



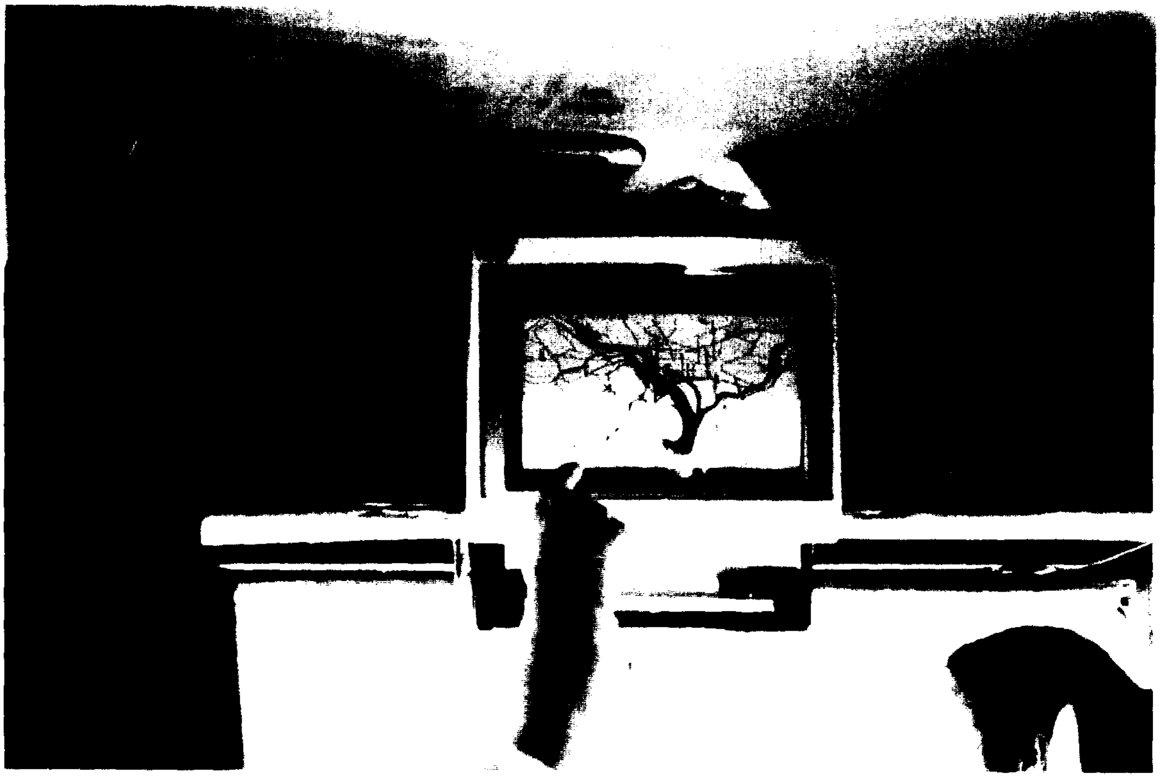
Base Station No. 2
U.S.A. Today Building



Columbia Plaza Base Site



Columbia Plaza Site
(Viewed toward Key Bridge)



Mobile Application Terminal
(MAP) - TRACKNET™

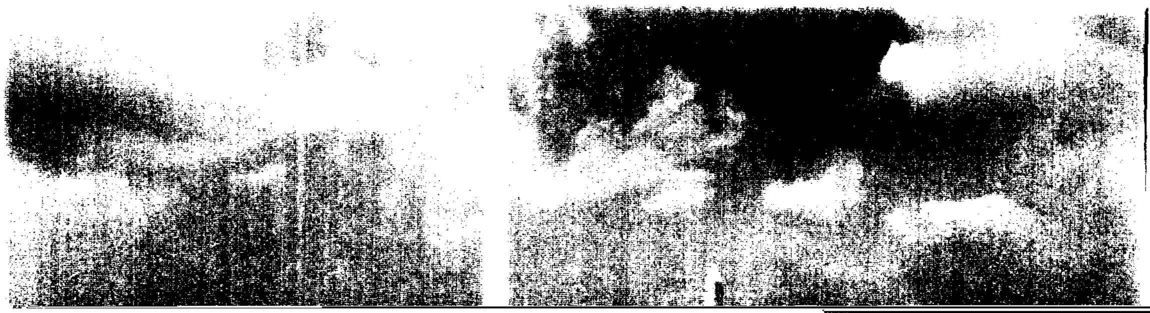


Table 2

Model of expected packet messaging rates to satisfy requirements of effective IVHS Traveller & Traffic Information Systems

DATA ASSUMPTIONS

Message size assumptions - bytes	Out-bound	In-bound	rate - per	unit
Public Safety message with directions	500	10	2	hr
Public Safety message without directions	80	10	2	hr
Dispatch message with directions	500	20	2	hr
Dispatch message without directions	80	20	2	hr
Traveller Info message — initial	1000	100	1	trip
Traveller info message — re-route	500	50	0.5	trip
Broadcast message - incidents	350		5	hr
Bus Scedule message	200	50	1	hr
Busy period duration in Hours	3			
Assumed Bytes per packet	20			
% of all non-fleet vehicles IVHS capable	3%			
% of all fleet vehicles (other than Safety & Transit) IVHS capable	10%			
% of Public Safety & Transit fleets active during peak period	90%			
% of Commercial & Other fleets active during peak period	12%			
% of other vehicles using traveller info during peak period	50%			
Transit update rate (per minute)	2			

Traveller Information Systems Data Traffic

Model Metro Population — Millions	1	2	4	6
Public Safety Vehicles	1,200	2,400	4,440	7,200
Busses and transit vehicles	600	1,200	2,220	3,600
Vehicles in Commercial fleets with 4 or more vehicles	99,000	198,000	366,300	594,000
Vehicles in business fleets with < 3 vehicles or Govt fleets	69,000	138,000	255,300	414,000
Total active fleet vehicles	21,780	43,560	80,586	130,680
Total active other vehicles	65,487	130,973	242,301	392,920
Total active fleet vehicles using IVHS Information systems	2,178	4,356	8,059	13,068
Other vehicles using traveller information systems	1,965	3,929	7,269	11,788
% of Total metro vehicles IVHS capable	**4.5%**	**4.5%**	**4.5%**	**4.5%**
instantaneous % of vehicles active during peak period that are IVHS capable	**0.5%**	**0.5%**	**0.5%**	**0.5%**
Public Safety not including data-base retreval - data pkts per peak period	773,182	1,546,364	2,860,773	4,639,091
Fleet - data packets during peak period	519,750	1,039,500	1,923,075	3,118,500
Transit - data & update packets during peak period	212,220	424,440	785,214	1,273,320
Other non-fleet - data packets during peak period	321,480	642,960	1,189,476	1,928,880
Broadcast & Other IVHS - data pkts during peak period	285	570	1,055	1,710
Total airtime packets (time-slots) per hour	608,972	1,217,945	2,253,197	3,653,834
Total IVHS info-system requirements (time-slots) pkt/s	**169**	**338**	**626**	**1,015**
Total IVHS Radio-locating Comm System requirements - Sum of Monitoring & Traveller Information - pkt/s	**342**	**684**	**1,265**	**2,051**
Total IVHS Data requirements - Approx equivalent bits/second with no allowance for radio-location by alternate location technologies like GPS	68,369	136,739	252,966	410,216

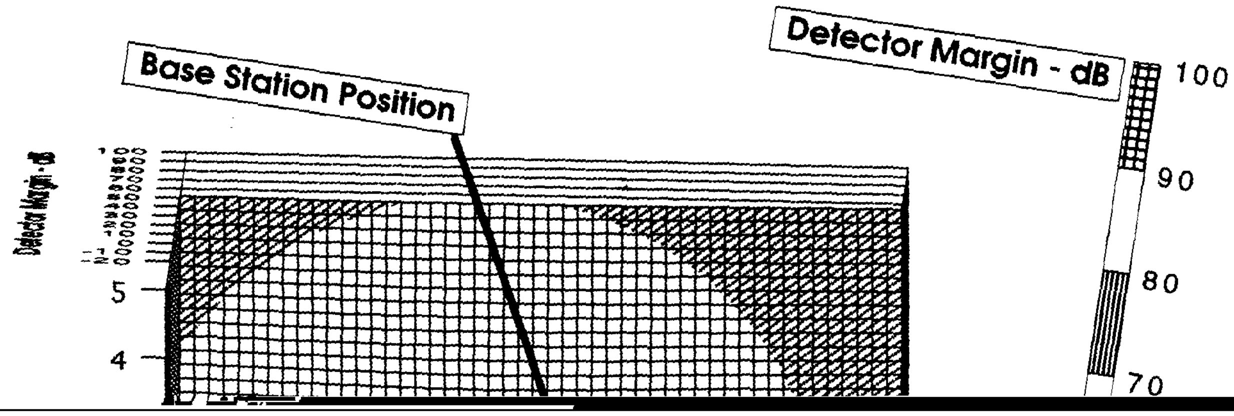
Table 3 — **Effects of Communication system overheads on overall subscriber capacity & cost**

	% overhead	1.00	Aggregate Subsciber Capacity		1,000,000
# of Firms timesharing	1	2	4	8	16
Capacity/firm	1,000,000	500,000	250,000	125,000	62,500
overhead each	10,000	10,000	10,000	10,000	10,000
Aggr Cap	1,000,000	990,000	970,000	930,000	850,000
decrease %	0.0%	1.0%	3.0%	7.0%	15.0%
			% decrease in aggregate capacity		
% overhead					
1.000%	0.00%	1.00%	3.00%	7.00%	15.00%
1.189%	0.00%	1.19%	3.57%	8.32%	17.84%
1.414%	0.00%	1.41%	4.24%	9.90%	21.21%
1.682%	0.00%	1.68%	5.05%	11.77%	25.23%
2.000%	0.00%	2.00%	6.00%	14.00%	30.00%
2.378%	0.00%	2.38%	7.14%	16.65%	35.68%
2.828%	0.00%	2.83%	8.49%	19.80%	42.43%
3.364%	0.00%	3.36%	10.09%	23.55%	50.45%
4.000%	0.00%	4.00%	12.00%	28.00%	60.00%
			% increased cost of residual service		
% overhead					
1.000%	0.00%	1.01%	3.09%	7.53%	17.65%
1.189%	0.00%	1.20%	3.70%	9.08%	21.71%
1.414%	0.00%	1.43%	4.43%	10.99%	26.92%
1.682%	0.00%	1.71%	5.31%	13.34%	33.74%
2.000%	0.00%	2.04%	6.38%	16.28%	42.86%
2.378%	0.00%	2.44%	7.68%	19.97%	55.46%
2.828%	0.00%	2.91%	9.27%	24.69%	73.69%
3.364%	0.00%	3.48%	11.22%	30.80%	101.83%
4.000%	0.00%	4.17%	13.64%	38.89%	150.00%

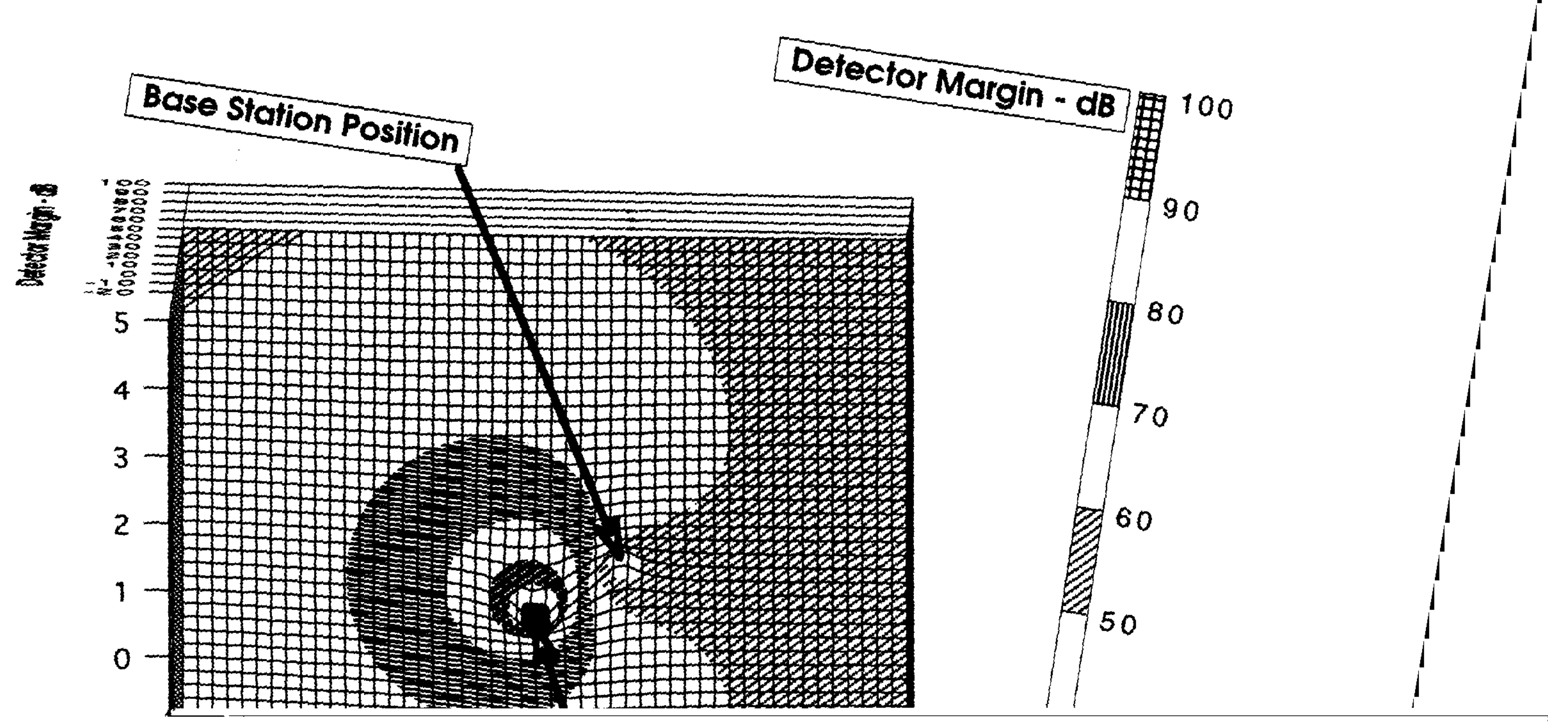
Table 4-1						
Demographics & Traffic Charateristics of five Metropolitan areas (1990)						
DEMOGRAPHICS	Baltimore	Minn-St.Paul	Phoenix	San Diego	St Louis	Average
Population (000's)	1991	2055	1920	2294	1950	2042
Square miles	765	956	971	680	694	821
Persons per sq mile	2603	2063	1977	3374	2810	2487
MILAGE						
Freeway & Expressway	237	294	98	230	268	225
Principal Arterials	406	132	731	243	529	408
Minor arterials	512	916	536	764	679	681
Collectors & Local	4793	7609	6031	4461	5690	6117
Total Freeways & Arterials	1155	1342	1385	1237	1474	1315
Total all roads	5948	8951	9396	5698	7164	7431
Freeways per sq mile	0.31	0.3	0.1	0.34	0.38	0.27
Freeway & Arterial per sq mile	1.51	1.35	1.41	1.52	2.12	1.6
Roadway miles per 1000 people	3	4.4	4.9	2.5	3.7	3.6
DAILY VEHICLE MILES TRAVELLED (VMT)		(Millions)				
Freeways & Expressways	15.8	17.8	7.9	27.7	18.4	17.5
Principal Arterials	9.8	3.5	17.5	6.8	11.2	9.8
Minor Arterials	5.7	11.3	4.7	10.7	7.7	8
Collectors & Local	5	10.4	9.5	6.4	8	7.9
Total Freeways & Arterials	31.4	32.8	30.1	45.2	37.3	35.9
Total Daily VMT	38.4	43.2	39.7	51.6	45.3	43.2
OTHER STATISTICS						
Freeway & Arterials DVMT/Milage (000s)	27.2	24.4	22.1	36.6	25.3	26.9
Freeways as % of total Milage	0.04	0.03	0.01	0.04	0.04	0.03
% DVMT served by Freeways	0.43	0.41	0.2	0.54	0.41	0.41
Freeways & arterials as % of total milage	0.19	0.15	0.15	0.22	0.21	0.18
% of DVMT on freewways & arterials	0.85	0.76	0.76	0.88	0.82	0.82

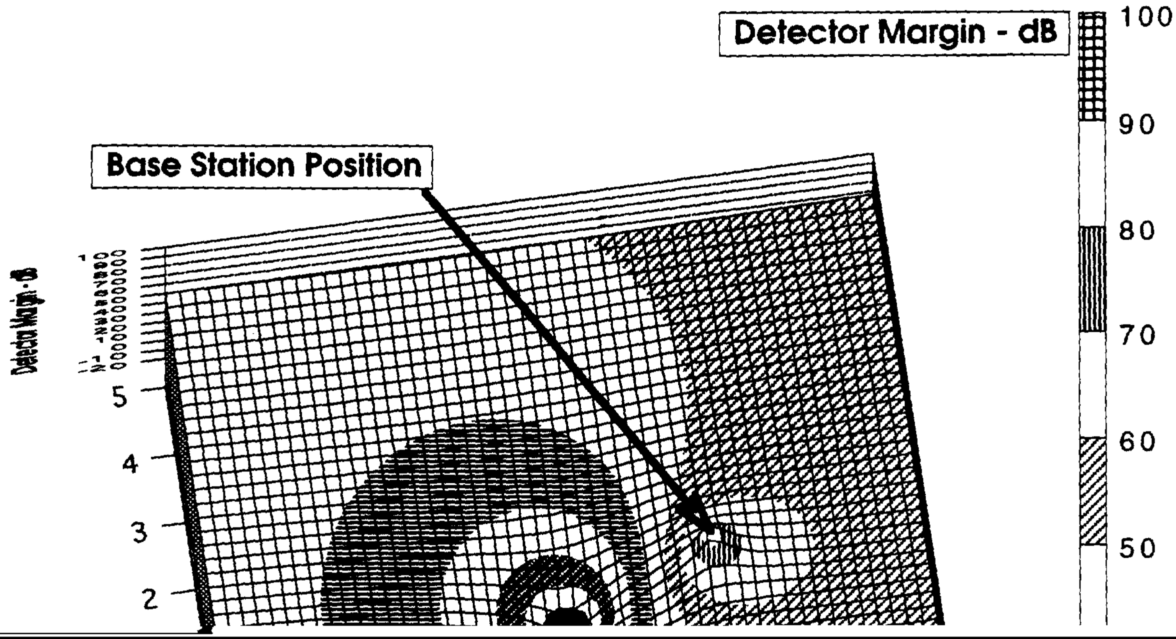
Table 4.2 Area-wide Peak Data

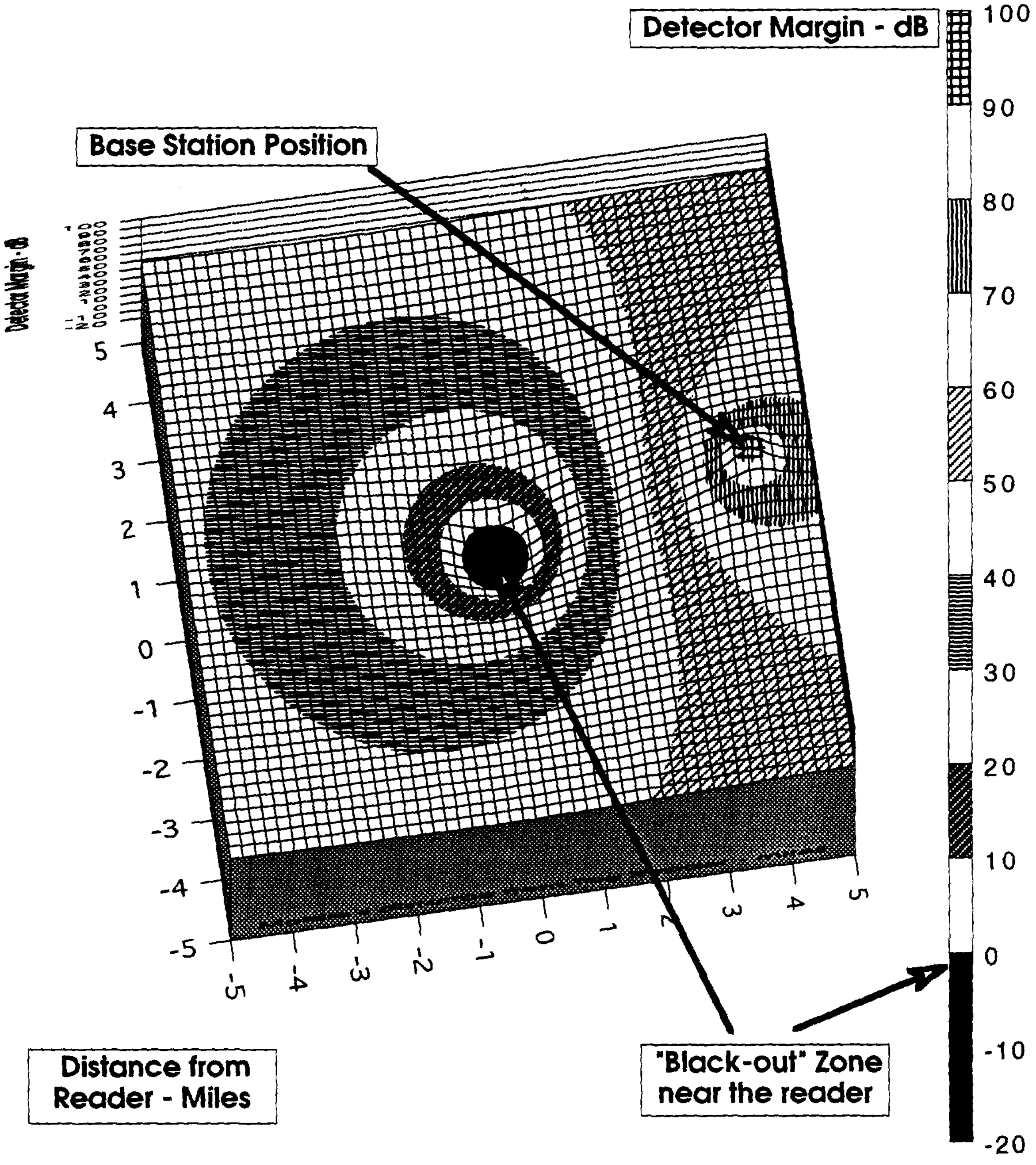
Table 4.2	Area-wide daily & Peak period Traffic data			
Variable	**Value**	**Units**	**Code**	**Basis**
Area-Wide Traffic				
Population of metro area	2000	000s	Pop	Based on 5 metro areas (4.1)
Size of metro area	820	sq miles		Based on 5 metro areas (4.1)
Miles of Freeways & arterials	1315	miles		Based on 5 metro areas (4.1)
Avg. side of sq grid for area	28.6	miles		
Number of Automobiles	1140	000s	Autos	=0.57 * Pop
Number of Vehicles	1530	000s	Veh	=1.34 * Autos
Trips/Vehicle/day	3		TVD	Estimated
Avg trip length	9.5	miles		Estimated
Total daily vehicle trips	4580	000s	Trips	= Veh * TVD
Total daily VMT	43.5	millions	DVMT	= Trips * TripLength
Peak Period				
Duration of AM or PM Peak Period	3	hours	PL	Estimated
Fraction of VMT in Peak Period	0.3		PkFr	Estimated
VMT in Peak Period	13.1	million	pkVMT	= DVMT * PkFr
Avg. Speed in peak	25	mph	Spd	estimated
Avg. trip length in peak	11	miles	TL	estimated
Avg. trip duration in peak	26.4	min	TT	= Spd * TL
Number of trips in peak period	1190	000s	PkTp	= pkVMT/TL
Trip Rate during peak	6600	per minute	Rate	= PkTp/PL
Steady state time within peak	20	minutes	M	Est. Steady State: > cycle time; < Avg. trip time
Avg. number of vehicles on road during peak (steady state)	174	000s	VoR	= Rate * TT
Fraction of peak VMT on major roads (frewways & arterials)	0.82		FVMR	estimated
Incidents per vehicle in M minutes	0.00013		IVM	Derived from 16 million VMT
Number of reportable incidents on major roads in M minutes	19			IVM * VoR * FVMR



Base Station Position
Detector Margin - dB
100
90
80
70
Detector Margin - dB
5
4

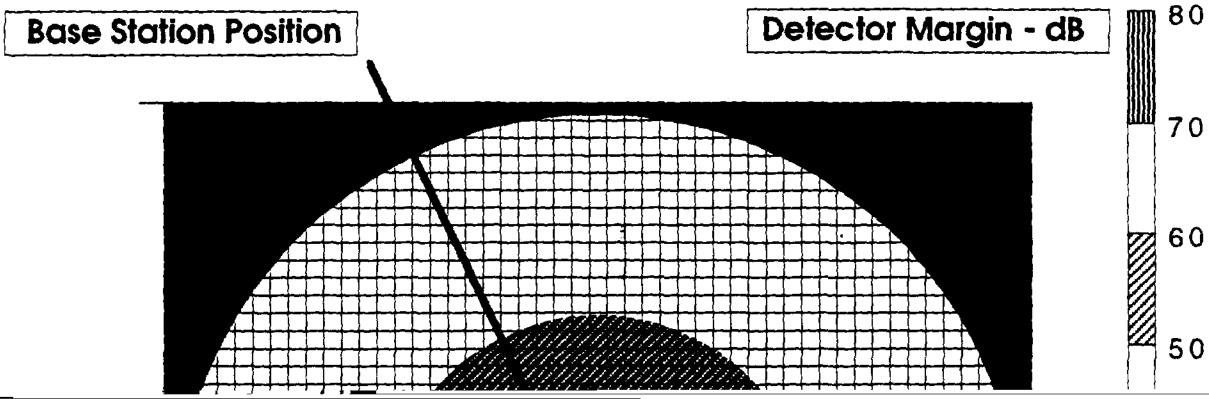

Base Station Position
Detector Margin - dB
100
90
80
70
60
50
5
4
3
2
1
0

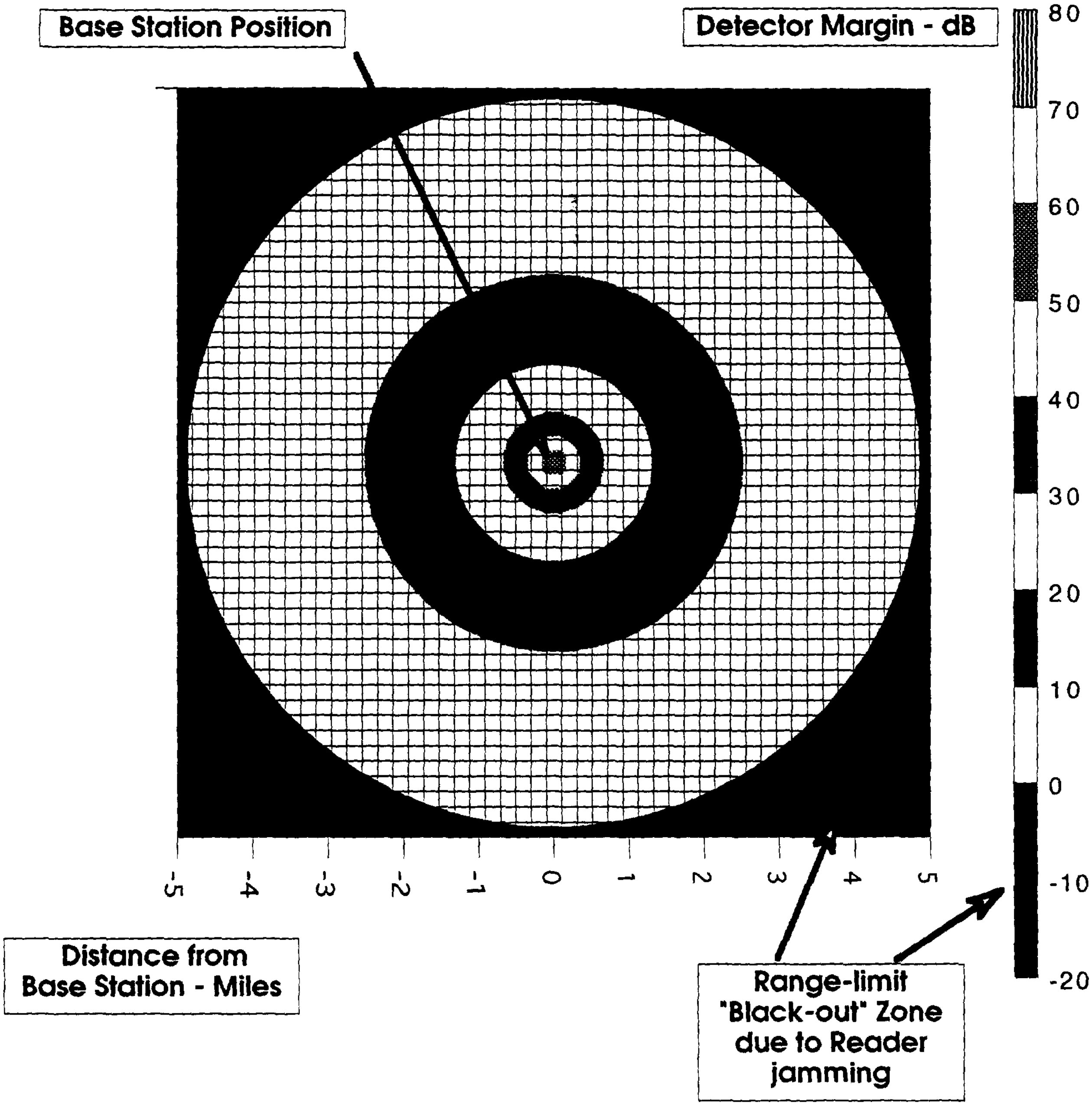

Detector Margin - dB
100
90
80
70
60
50
Base Station Position
Detector Margin - dB
5
4
3
2



Base Station Power	60.0	dBm
Jammer Power	35.0	dBm
Plot range	5.0	±miles from Jammer

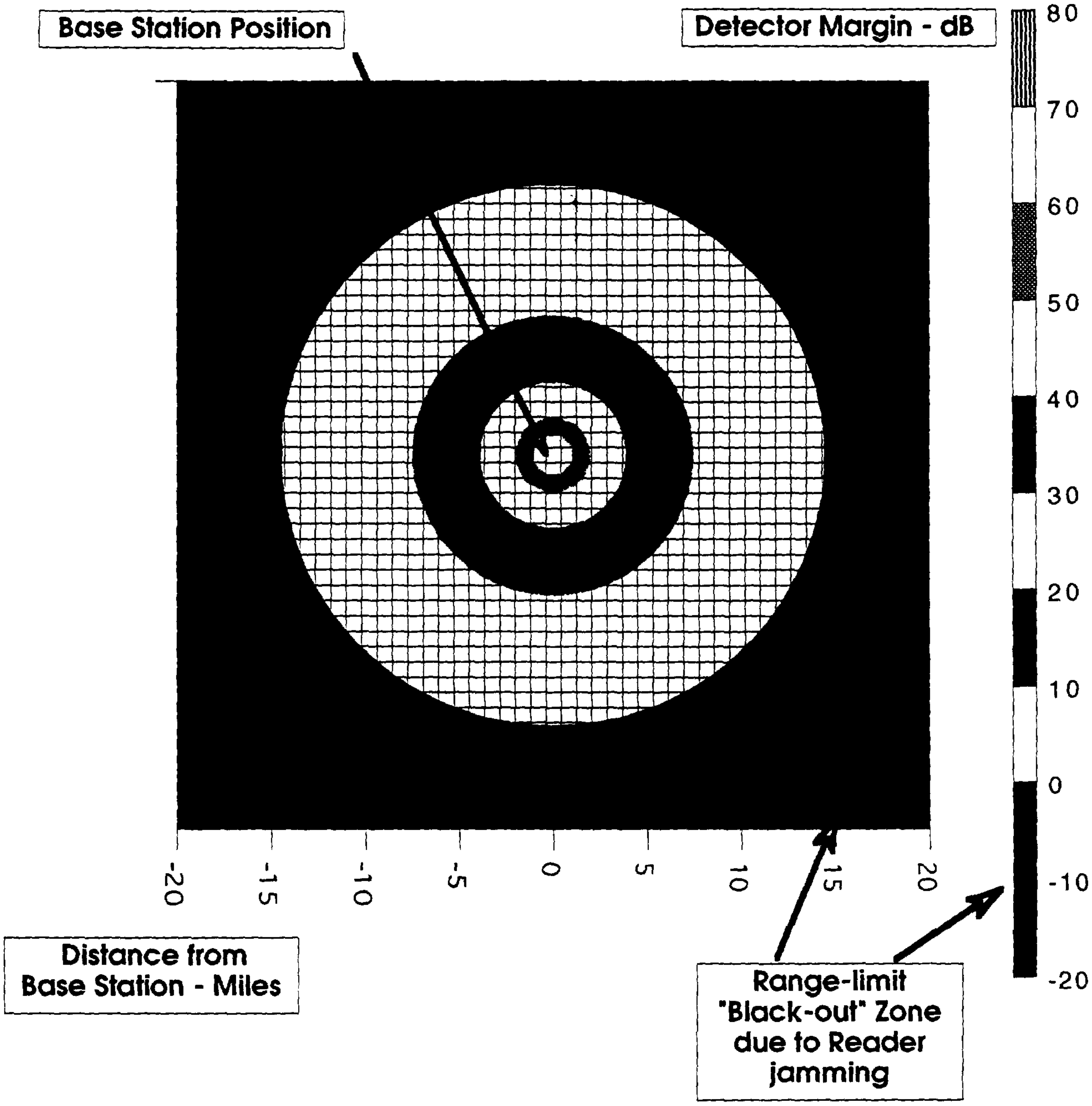
Figure 7
Wide-area Mobile Receiver's Detector-margin @ 50% Communication Closure Probability Jammer to Base distance 4.0 miles


Base Station Position
Detector Margin - dB
80
70
60
50



Power-mobile	48.0	dBm	Mobile ht	3 meters
Jammer Power	35.0	dBm	Jammer ht	3 meters
Plot range	5.0	±miles from Jammer	Base ht	30 meters

Figure 9
Wide-area Base Receiver's Detector-margin
@ 50% Communication Closure Probability
Jammer to Base distance 1.0 miles



Power-mobile	48.0	dBm	Mobile ht	3 meters
Jammer Power	35.0	dBm	Jammer ht	3 meters
Plot range	20.0	±miles from Jammer	Base ht	30 meters

Figure 10
Wide-area Base Receiver's Detector-margin
@ 50% Communication Closure Probability
Jammer to Base distance 2.0 miles

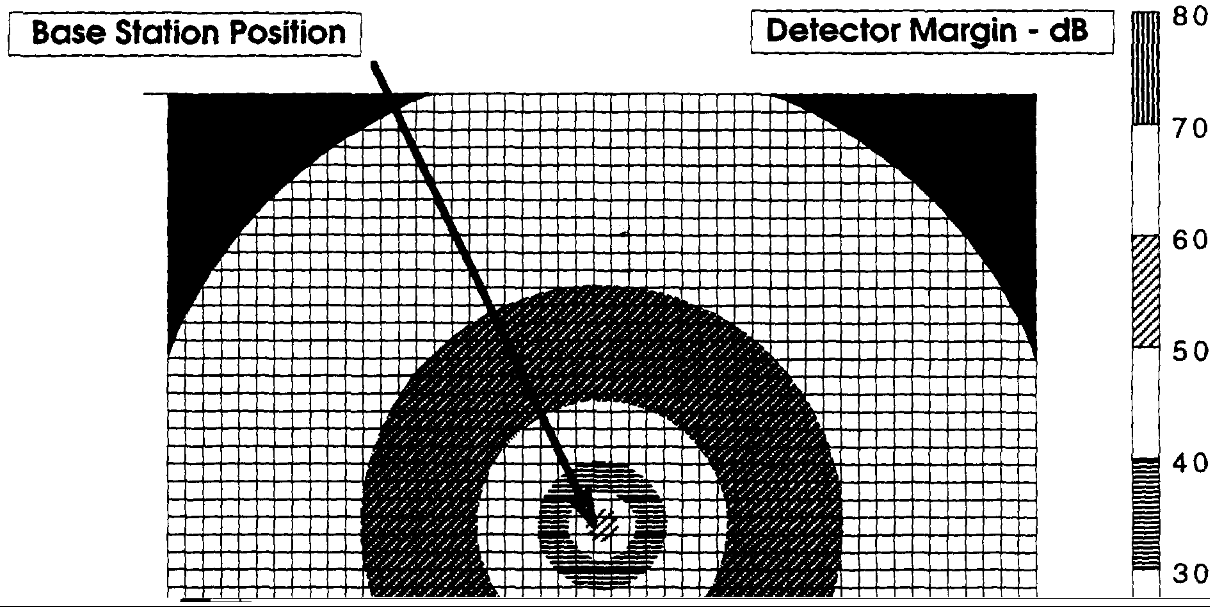
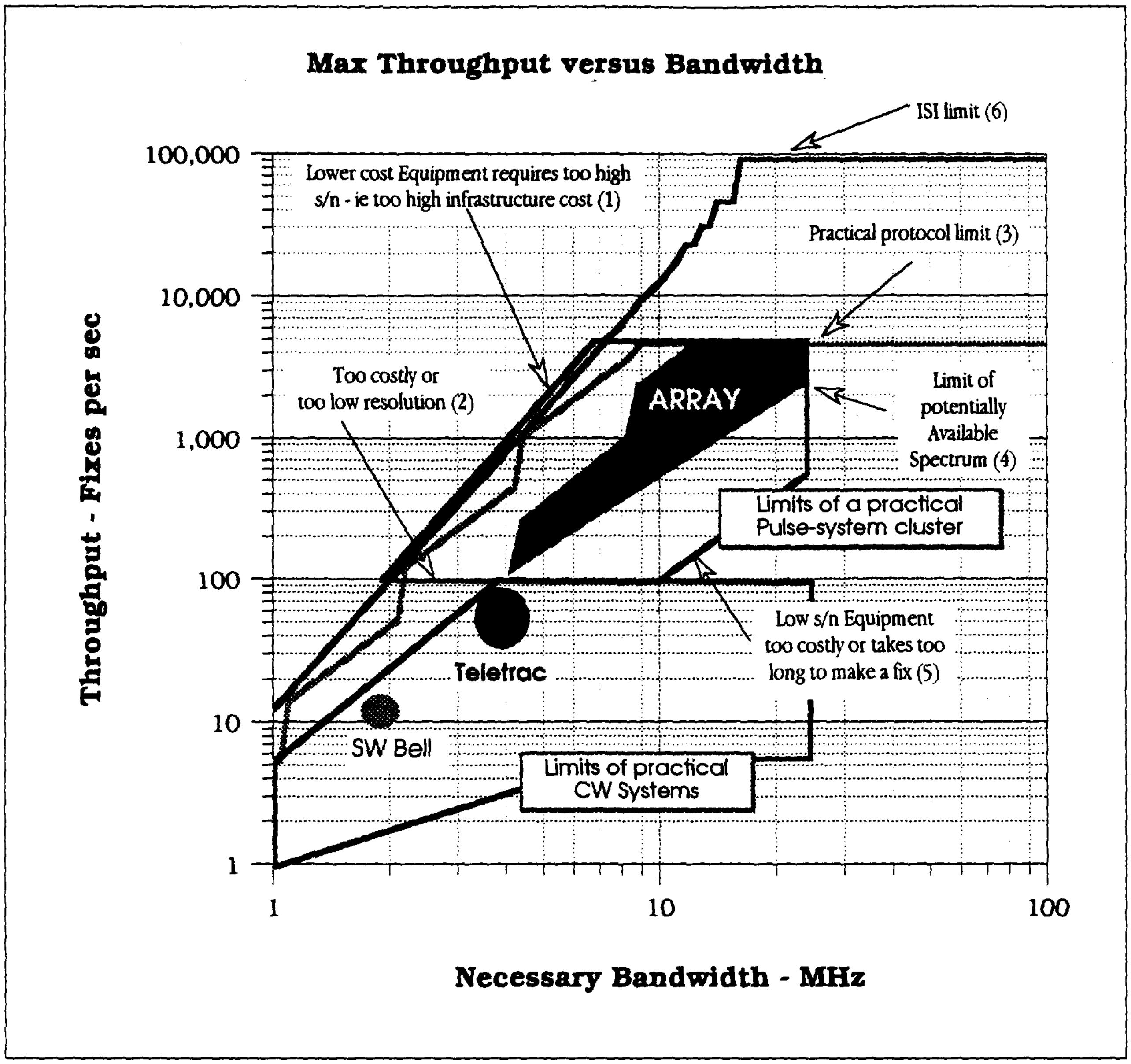

Base Station Position
Detector Margin - dB
80
70
60
50
40
30

Figure 12. Illustration of Bounds



The figure depicts the relationships between position-fixing throughput versus occupied bandwidth. Multilaterating systems such as ARRAY are bound by somewhat arbitrary but practical limits illustrated by the pentagon having sides (1) through (5). See Exhibit A to Pinpoint's opening comments in PR Docket 93-61 for a more complete discussion of the factors affecting the position-fixing rates for different automatic vehicle monitoring multilateration system approaches.

The theoretical curve shows the possible throughput for a particular time resolution and signal-to-noise ratio. It is limited at wider bandwidths by inter symbol interference (ISI) that would result from the pulse-expansion sequence duration being longer than the separation between pulses. The derivation of the line presumes an unconstrained size to the length of suitable expansion & compression sequences. However, the practical curve (stepped ramp) shows the results obtained by constraining the sequences to real values, (typically of length 2^n-1, where n has integer values). Practical rates are further limited at larger bandwidths to a maximum of about 5000 fixes per second by the requirements of typical radio-communication protocols, involved in the control and management of the radio-location process (addressing, operation codes, status, check characters, etc.) This requirement forms side (3) of the bounding area.

As the s/n ratio is increased, or the required resolution is reduced, the throughput increases. However, increasing the s/n ratio increases the cost of the infrastructure by requiring more base stations per square mile or more power output per base station, and the timing resolution can only be reduced to meet the operational requirements of the overall system. This creates the bound (1).

Boundary (2) is mainly economic one. At some ratio of infrastructure cost to system

The

Appendix C

Pinpoint Communications, Inc.

ANALYSIS OF THE ECONOMICS OF CHANNEL EXCLUSIVITY FOR WIDE-AREA LOCATION MONITORING SYSTEMS

by

W. Wayne Stargardt